Generation and Application of Femtosecond X-rays from the Advanced Light Source

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Abstract:

An important new area of research in chemistry, condensed matter physics, and biology is the application of x-ray techniques on a femtosecond time scale to investigate structural dynamics, i.e. atomic motion and rearrangement associated with ultrafast chemical reactions, phase transitions, vibrational energy transfer, surface processes etc. The fundamental time scale for such phenomena is an atomic vibrational period, ~100 fs. While powerful structural probes including x-ray diffraction and EXAFS are widely used at modern synchrotrons for probing the "static" structure of materials, the time resolution of synchrotron sources is limited by the duration of the stored electron bunches, typically >30 ps.

We have recently demonstrated the generation of femtosecond synchrotron pulses from the Advanced Light Source using a novel laser slicing technique[1,2]. Femtosecond optical pulses are used to energy-modulate an ultrashort slice of a stored electron bunch via co-propagation through a resonantly tuned wiggler. The energy-modulated electrons are then separated from the remainder of the bunch in a dispersive section of the storage ring, and used to generate femtosecond x-rays. We directly measure synchrotron pulses of ~300 fs duration by cross-correlating the visible radiation from a bend magnet with a femtosecond laser pulse.

A new bend-magnet beamline is being commissioned the ALS for generating 100 fs x-rays to investigate structural dynamics in condensed matter using time-resolved optical pump and x-ray probe techniques. Future plans include the development of a small-gap undulator beamline providing high-brightness femtosecond x-rays for time-resolved measurements of atomic motion.

1. A.A. Zholents, M.S. Zolotorev, *Phys. Rev. Lett.* **76**, 912-915 (1996).
2. R.W. Schoenlein, S. Chattopadhyay, H.H.W. Chong, T.E. Glover, P.A. Heimann, C.V. Shank, A. Zholents, and M. Zolotorev, *Science*, **287**, 2237-2240, 2000.